discussed extensively below. Claim 10 has been amended to be dependent upon claim 9, instead of claim 1, to ensure proper antecedent basis. The specification is also amended to ensure proper reference numbers relating to descriptive elements of the invention as referenced in the respective figures.

Claims 27-30 are added by this Amendment. Support for claim 27 is found in the specification at, for example, page 24, lines 11-13. Support for claim 28 is found in the specification at, for example, page 11, lines 6-20. Support for claim 29 is in original claim 13. Support for claim 30 is found in the specification at, for example, page 41, lines 3-8.

The attached Appendix includes a marked-up copy of each rewritten paragraph (37 C.F.R. §1.121(b)(1)(iii)) and claim (37 C.F.R. §1.121(c)(1)(ii)).

I. <u>Claim Rejections Under 35 U.S.C. §112, First Paragraph</u>

Claim 6 was rejected by the Patent Office under 35 U.S.C. §112, first paragraph as allegedly being based on a disclosure which is not enabling. The rejection is respectfully traversed.

In particular, the Patent Office alleged that the term "at%" is not enabling. Applicants submit that the term "at%" clearly means "atomic%."

In the original PCT application (which the present application is a U.S. national stage of), for example, in the second paragraph of Example 1, it is stated that "Over this transparent substrate 2 were formed chromium nitride (CrN) film (Cr: 80 atomic%), N: atomic% (hereafter called at%); film thickness 150Å) as a first shading film ...". Applicants submit that the omission of the phrase "hereafter called at%" and initial references to "atomic%" resulted from a translational error. A proper translation of this portion of the original PCT application and this portion of the original PCT application are attached hereto for the convenience of the Patent Office.

Further, by this Amendment, Applicants revise the translated present specification and claim 6 to recite "atomic%" instead of "at%" in order to more clearly set forth the aspects of the invention and expedite prosecution of the application. As the original PCT application provides explicit support for these amendments, such do not constitute new matter.

For the foregoing reasons, reconsideration and withdrawal of the rejection are respectfully requested.

II. Claim Rejections Under 35 U.S.C. §112, Second Paragraph

A. Claims 1-26

Claims 1-26 were rejected by the Patent Office under 35 U.S.C. §112, second paragraph as allegedly being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicants regard as the invention. In particular, the Patent Office alleges that the terms "light-shielding function," "opaque function" and "non-transmitting function" are unclear. The rejection is respectfully traversed.

The phrase "shading function" clearly represents the function to shade light by the present invention. The phrases "light-shielding function," "opaque function" and non-transmitting function" were included by the Applicants to further exemplify the shading properties of the present invention.

As the phrases are allegedly deemed indefinite by the Patent Office, Applicants delete the phrases "light-shielding function," "opaque function" and non-transmitting function" from claims 1, 2, 4 and 14-16 to expedite prosecution.

For the foregoing reasons, Applicants respectfully request reconsideration and withdrawal of the rejection.

B. Claim 6

Claim 6 was rejected by the Patent Office under 35 U.S.C. §112, second paragraph as allegedly being indefinite for failing to particularly point out and distinctly claim the subject

matter which Applicants regard as the invention. In particular, the Patent Office alleges it is unclear whether the term "at%" refers to atomic or atmospheric percentage. The rejection is respectfully traversed.

As set forth above, the term "at%" means "atomic%." By this Amendment, claim 6 is amended to recite "atomic%" instead of "at%." Reconsideration and withdrawal of the rejection are respectfully requested.

C. Claim 9

Claim 9 was rejected by the Patent Office under 35 U.S.C. §112, second paragraph the Patent Office alleging insufficient antecedent basis for the limitation "the same metal material." The rejection is respectfully traversed.

By this Amendment, claim 1 is amended to recite that "the thin film contains a metal material." Support for the amendment is found in the original specification at, for example, page 10, lines 4-8. The phrase "a metal material" in claim 1 provides adequate antecedent basis for "the same metal material" recited in claim 9 (dependent upon claim 1). Thus, Applicants submit that claim 9 fulfills all the requirements of 35 U.S.C. §112, second paragraph.

Reconsideration and withdrawal of the rejection are respectfully requested.

D. Claim 10

Claim 10 was rejected by the Patent Office under 35 U.S.C. §112, second paragraph the Patent Office alleging insufficient antecedent basis for the limitation "in the nitride film." The rejection is respectfully traversed.

By this Amendment, the dependency of claim 10 has been changed from claim 1 to claim 9. Claim 9 clearly recites the presence of "a nitride film." Thus, claim 10 contains proper antecedent basis for "the nitride film" by being dependent upon claim 9.

Reconsideration and withdrawal of the rejection are respectfully requested.

E. Claim 13

Claim 13 was rejected by the Patent Office under 35 U.S.C. §112, second paragraph the Patent Office alleging insufficient antecedent basis for the limitation "in the nitride film." The rejection is respectfully traversed.

By this Amendment, claim 13 is amended to delete language referencing "the nitride film." As the cited language has been deleted from the claim, Applicants submit that claim 13 fulfills all the requirements of 35 U.S.C. §112, second paragraph.

Reconsideration and withdrawal of the rejection are respectfully requested.

F. Claim 21

Claim 21 was rejected by the Patent Office under 35 U.S.C. §112, second paragraph the Patent Office alleging insufficient antecedent basis for the limitation "and the same metal contained in the thin film." The rejection is respectfully traversed.

By this Amendment, claim 14 has been amended to recite that the thin film contains a metal material. Claim 21 is dependent upon claim 14, and thus has proper antecedent basis for "the same metal contained in the thin film."

Reconsideration and withdrawal of the rejection are respectfully requested.

III. Claim Rejections Under 35 U.S.C. §103(a)

The present invention claims a photomask blank comprising at least a thin film having a shading function formed over a transparent substrate. The thin film contains a metal material and helium. It contains helium to such an extent that the film stress of the thin film can be reduced to be a desired film stress. (Claim 1).

The present invention further claims a method of manufacturing a photomask blank in which a sputtering target is disposed in a vacuum chamber into which an atmosphere gas has been introduced. At least a thin film having a shading function is formed over a transparent substrate by sputtering. The correlation of the amount of helium gas contained in the

atmosphere gas and the film stress of the thin film is determined ahead of time. The helium gas content is determined from the correlation so that the thin film will have a film stress such that the obtained mask pattern will have the desired pattern position precision and the thin film is formed by sputtering in an atmosphere gas having this helium gas content. (Claim 14).

A. Babich

Claims 1-3, 6-8, 12-20, 22 and 24-26 were rejected by the Patent Office under 35 U.S.C. §103(a) as allegedly being obvious over Babich (U.S. Patent No. 5,830,332). The rejection is respectfully traversed.

Babich teaches a method of reactive sputtering for depositing an amorphous hydrogenated carbon film (a-C:H) from an argon/hydrocarbon/hydrogen/oxygen plasma. The films produced by Babich are optically transparent in the visible range and partially absorbing at ultraviolet (UV) and deep UV (DUV) wavelengths.

Babich fails to teach or suggest the present invention. In particular, Babich fails to teach or suggest a photomask blank having a thin film, wherein the thin film contains a metal material. Babich instead teaches an amorphous hydrogenated carbon thin film, which is not a thin film containing a metal material as claimed in the present application.

Further, Babich teaches a method of forming an amorphous hydrogenated carbon thin film by sputtering using a helium gas. However, Babich fails to teach or suggest whether or not the formed thin film contains helium. Nor does Babich teach or suggest whether helium, if even contained in the Babich thin film, is contained in the amorphous hydrogenated carbon thin film to such an extent that the film stress can be reduced to a desired film stress.

Babich also does not teach or suggest any advantages to having the thin film contain helium when formed. Although Babich teaches that the helium gas is present in order to

dilute the hydrocarbon gas, Babich fails to teach or suggest that the helium gas may be used to reduce film stress of the thin film.

Finally, nothing taught or suggested in Babich describes whether or not the amorphous hydrogenated carbon thin film has film stress. Thus, it would not have been obvious for one of ordinary skill in the art to have been led to the present invention with a reduced film stress by a reading of Babich, wherein film stress is not even mentioned.

For the foregoing reasons, Applicants submit that Babich fails to teach or suggest the present invention. Reconsideration and withdrawal of the rejection are respectfully requested.

B. Miyashita

Claims 1-8, 10-20 and 22-26 were rejected by the Patent Office under 35 U.S.C. §103(a) as allegedly being obvious over Miyashita (U.S. Patent No. 5,738,959). The rejection is respectfully traversed.

Miyashita teaches a halftone phase shift photomask having a sufficiently high transmittance for light of short wavelength and usable for high-resolution lithography. The halftone phase shift photomask has, on a transparent substrate, a halftone phase shift layer which includes at least one layer composed mainly of a chromium compound. The chromium compound contains at least fluorine atoms in addition to chromium atoms.

Miyashita teaches that the thin film contains chromium. However, it is well known in the art that a thin film containing chromium has a high film stress. Thus, one of ordinary skill in the art would not have been led to the present invention by Miyashita because Miyashita teaches a thin film wherein high film stress will be characteristic of the produced thin film due to presence of chromium. Further, Miyashita fails to teach or suggest any means or reasons to reduce this film stress wherein chromium is present in the thin film.

Further, Miyashita teaches that a helium gas is used as a kind of inactive gas during the formation of the thin film containing chromium. (See column 4, lines 49-60). Nowhere does Miyashita teach or suggest that helium is (1) present in the thin film, or (2) able to reduce film stress levels as described in the present invention. Thus, one of ordinary skill in the art would not have been led to the present invention by the teachings or suggestions or Miyashita.

Applicants also submit that one of ordinary skill in the art would not have been motivated to combine the teachings of Babich and Miyashita since Babich teaches a non-metal containing thin film and Miyashita teaches a metal containing (chromium) thin film. Even if one were to argue that the teachings of Babich and Miyashita are in the same technical field as a thin film mask for lithography, it would not be easily understood to one of ordinary skill how to apply the teachings based on a non-metal containing thin film formation of Babich to the metal containing thin film formation of Miyashita to find the present invention wherein the film stress is reduced.

For the foregoing reasons, Applicants submit that Miyashita fails to teach or suggest the present invention. Reconsideration and withdrawal of the rejection are respectfully requested.

IV. Conclusion

In view of the foregoing amendments and remarks, Applicants submit that this application is in condition for allowance. Favorable reconsideration and prompt allowance of claims 1-30 are earnestly solicited.

Should the Examiner believe that anything further would be desirable in order to place this application in better condition for allowance, the Examiner is invited to contact Applicants' undersigned representative at the telephone number listed below.

Respectfully submitted,

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JAO:JSA:DML/rxg

Attachment:
Appendix

Date: January 22, 2002

OLIFF & BERRIDGE, PLC
P.O. Box 19928
Alexandria, Virginia 22320
Telephone: (703) 836-6400

DEPOSIT ACCOUNT USE AUTHORIZATION
Please grant any extension necessary for entry;
Charge any fee due to our Deposit Account No. 15-0461

APPENDIX

Changes to Specification:

Page 16, lines 11-23:

With the photomask blank 1 pertaining to Example 1 shown in Figure 1, a quartz glass substrate measuring 5 inches × 5 inches × 0.09 inch an whose main surface and end face had undergone precision polishing was used as the transparent substrate 2. Over this transparent substrate 2 were formed a chromium nitride (CrN) film (Cr: 80 ~~at%~~ atomic%, N:20 ~~at%~~ atomic% (hereafter called at%); film thickness 150 Å) as a first shading film (light-shielding film, opaque film, non-transmitting film) 3, a chromium carbide (CrC) film (Cr: 94 at%, C: 6 at%; film thickness: 600 Å) as a second shading film (light-shielding film, opaque film, non-transmitting film) 4, and a chromium oxynitride (CrON) film (Cr: 30 at%, O: 45 at%, N: 25 at%; film thickness: 250 Å) as an anti-reflective film 5.

Page 17, lines 11-13:

Next, the characteristics of the photomask blank 1 in terms of manufacturing, and the effect thereof as a photomask blank 1, will be described.

Page 17, lines 14-17:

Figures 3 and 4 are schematic cross sections illustrating the methods for manufacturing the photomask blank 1 of Example 1 and the photomask 11 of Example 1, respectively.

Page 18, lines 9-18:

Quartz glass that absorbs little light with wavelength in the ultraviolet region, as is the case with the exposure light, is particularly good as the transparent substrate 2, but quartz glass generally results in more film stress than soda lime glass or aluminoborosilicate glass, which is thought to be due to different crystal seeds or differences in the coefficient of thermal expansion with a chromium film. Therefore, the present invention is suited to

combination with a quartz glass substrate which is suitable as a glass substrate for a photomask.

Page 18, line 19 to page 19, line 6:

Then, a CrC film with a thickness of 600 Å was formed as the second shading film (light-shielding film, opaque film, non-transmitting film) 4 as shown in Figure 3 (b) by reactive sputtering using a chromium target in a mixed gas atmosphere composed of argon methane and helium (Ar: 30 vol%, CH_4: 10 vol%, He 60 vol%, pressure 0.3 Pa, sputtering power: 1650 W, deposition rate: 3.4 nm/sec). The carbon content in the CrC film of the above photomask blank 1 was measured and found to be 6 at%, and the etching rate was 0.3 nm/sec. The crystal grain diameter of the CrC film was measured by transmission electron microscope (TEM) and found to be 1 to 7 nm.

Page 19, lines 7-14:

The method of the present invention for manufacturing a photomask blank 1 solves the problems mentioned above by having the helium serving as the inert gas be contained as a type of mixed gas. Figure 3 (b) here shows an example in which the helium content in the mixed gas is 60 vol%, but the proportions in which the gases are mixed in this mixed will be discussed in detail below on the basis of experimental results.

Page 19, line 23 to page 20, line 7:

The oxygen and nitrogen contents in the CrON film of the above photomask blank 1 were measured and found to be 45 at% oxygen and 25 at% nitrogen. The optical characteristics of the photomask blank 1 produced in this manner were measured using a commercially available apparatus, and at a wavelength of 365 nm, the optical density was 3.0 and the surface reflectance was 12%. There were no defects in any of the films, meaning that the film quality was good.

Page 20, lines 9-12:

The sheet resistance was measured for the photomask blank 1 of CrN/CrC/CrON films finally obtained, whereupon the conductivity was good, being 25 ohms per square or less. This indicates that charges tend not to build up between the CrON film and the resist during electron exposure.

Page 20, line 18 to page 21, line 9:

The specific heating method used for this analysis involved guiding the light from an infrared lamp outside the vacuum system into a measurement chamber through a rod of molten quartz, which is highly transparent, and placing a sample holder made of the above-mentioned opaque quartz on the upper end of the rod. A sample cut out in a size of 10 mm^2 from the photomask blank 1 obtained above is placed on the opaque quartz sample holder of the thermal desorption gas analyzer, and the sample is heated by infrared rays from below. The sample temperature is measured by a thermocouple in contact with the thin film surface. Here, the degree of vacuum was approximately 4×10^{-7} Pa and the temperature elevation rate was 10 to 60°C/min, and the measurement was made with a mass spectrometer for the gas desorption behavior of mass number (m/e) = 4 (He) when the room temperature was varied up to approximately 850°C.

Page 22, lines 12-22:

Thus, if helium is contained as a mixed gas in sputtering in the formation of the chromium carbide film, the diameter of the grains forming the CrC will be small (1 to 7 nm), a good thin film with no film stress will be obtained, and a photomask blank 1 with little change in flatness will be obtained. The mechanism of this is not certain, but is surmised to be that while the crystals of the CrC film become fine, they are not amorphous, and the admixture of helium (He) atoms that do not participate in the bonding of the chromium grains hinders the crystal growth of the chromium while the CrC is being formed.

Page 22, line 23 to page 23, line 8:

As shown in Figures 4 (a), a resist 6 was applied by coating over the CrON film serving as the anti-reflective film 5, and this was subjected to pattern exposure and developing to form a resist pattern as shown in Figure 4 (b). CrON not only has an anti-reflective function, but also has an anti-oxidizing function, and consequently its durability is good and it exhibits good characteristics for a photomask blank 1. Thus, adhesion is good with the resist used in a subsequent step, and the above-mentioned patterning can be carried out stably and to high precision.

Page 25, lines 9-17:

Even when the helium content in the mixed gas was about 40 vol%, a good film could be obtained by adjusting the sputtering power. When the helium content in the mixed gas was lowered to about 30 vol%, the change in flatness was approximately -1.8 μm, but the positional precision of the mask pattern in the photomask 11 produced using this photomask blank 1 was within a range that can be identified as passable. In terms of the positional precision of the mask pattern, it is preferable for the change in flatness to be -2 μm or less.

Page 25, line 23 to page 26, line 15:

Although not shown in the graph, a photomask blank 1 was produced by further lowering the sputtering power and setting the thin film deposition rate to 0.5 nm/sec, but no film stress that would pose a problem was generated, and the photomask blank 1, as well as the photomask 11 produced using this blank, underwent little change in flatness and has good pattern positional precision, within the passable range. Conversely, when a photomask blank 1 was produced by raising the sputtering power and setting the thin film deposition rate to approximately 6 nm/sec, no particles that would pose any particular problem were observed in the thin film, and the photomask blank 1, as well as the photomask 11 produced using this blank, were within the passable range. The sputtering gas pressure here was 0.2 to 0.6 Pa,

and the sputtering power was 950 to 3000 W. Preferably, due to the relationship with the film stress and film defects, the sputtering power should be 1200 to 2000 W.

Page 26, line 16 to page 27, line 7:

m/e = 4 (helium) desorption was observed with a thermal desportion gas analyzer, and it was shown that the films contained helium in the photomask blank 1 of Example 1 produced under the above sputtering conditions, but when the helium gas content in the mixed gas was varied to 80 vol%, 60 vol%, and 40 vol% and the m/e = 4 relative intensity (helium) was confirmed to increase in proportion to the helium content in the mixed gas. This tells us that the amount of helium contained in a film obtained by sputtering can be adjusted by adjusting the helium content in the mixed gas. The above-mentioned relative intensity is the quotient of dividing the integral intensity ratio in the pyrogram Figure 7 by the sample surface area ratio (in this case, the relative intensity was set at 1 when the helium gas content was 80 vol%).

Page 27, lines 8-21:

Thus, at least when forming the CrC film, film stress can be suppressed by introducing helium gas into the atmosphere gas, and a photomask blank 1 with good film quality can be obtained while ensuring a high yield, without any adverse effect of impurities from the target. Also, no particular film stress occurred when the CrC film was formed in a thickness of approximately 250 to 1100 Å and the CrON film in a thickness of approximately 200 to 300 Å, and it was possible to obtain a good photomask blank 1, as well as a good photmask 11 using this blank. It is also possible to suppress film stress by introducing helium gas during the formation of not only the CrC film but also the CrON film. A photomask blank 1 having even better film quality is obtained in this case.

Page 30, lines 7-22:

With the photomask blank ~~11~~ 31 pertaining to the example shown in Figure 8, a quartz glass substrate measuring 5 inches × 5 inches × 0.09 inch and whose main surface and end faces had undergone precision polishing was used as the transparent substrate 12. Over this transparent substrate 12 were formed the first shading film (light-shielding film, opaque film, non-transmitting film) 13 composed of chromium nitride film containing chromium and nitride (film thickness: 150 Å), a second shading film (light-shielding film, opaque film, non-transmitting film) 14 composed of a chromium carbide film containing chromium and carbide (film thickness 600 Å), and an anti-reflective film 15 composed of a chromium oxynitride film containing chromium, oxygen, and nitrogen (film thickness: 250 Å). The photomask ~~31~~ 32 shown in Figure 9 was patterned by etching the photomask blank of Figure 8.

Page 30, line 23 to page 31, line13:

Next, the methods for manufacturing the photomask blank 31 and photomask 32 of the present invention in Example 2 will be described. The transparent substrates ~~2~~ 12 composed of quartz glass and measuring 5 inches × 5 inches × 0.09 inch and whose main surface and end faces have undergone precision polishing are put on a substrate holder (pallet) and introduced into the inline continuous sputtering apparatus shown in Figure 6. In the simplest terms, this inline sputtering apparatus consists of three chambers as shown in Figure 6: an entry 21, a sputtering chamber (vacuum chamber) 22, and an exit chamber 23. These chambers are separated by partitions. The transparent substrates ~~2~~ 12 loaded on the pallet are conveyed in the direction of the arrow in the figure. The structure of the various chambers will be described in the pallet conveyance direction.

Page 31, line 14 to page 32, line10:

The entry chamber 21 is purged of air to create a vacuum on the inside. In the next chamber, the sputtering chamber 22, are formed shading films (light-shielding films, opaque films, non-transmitting films), such as chromium nitride (CrN) containing chromium and

nitrogen (the first shading film (light-shielding films, opaque films, non-transmitting film) 13) and chromium carbide (CrC) containing chromium and carbon (the second shading film (light-shielding films, opaque films, non-transmitting film) 14), and anti-reflective film 15, such as chromium oxynitirde (CrON) containing chromium, oxygen, and nitrogen. In other words, the film formation steps illustrated in Figure 3 are carried out. Although not shown in the figures, a plurality of chromium targets for forming the first and second shading films 13, 14 (light-shielding films, opaque films, non-transmitting films) and the anti-reflective film 15 are provided inside the sputtering chamber 22, and a plurality of valves for introducing atmosphere gas are provided near these targets. The last chamber, the exit chamber 23, is purges of air to create a vacuum on the inside, just as with the entry chamber 21.

Page 32, lines 11-17:

When a photmask blank 31 is manufactured using the inline continuous sputtering apparatus described above, the first step is to introduce a pallet loaded with the quartz glass transparent substrates ~~2~~ 12 into the entry chamber 21. The entry chamber 21 is then changed from the atmospheric pressure to a vacuum, after which the pallet is conveyed into the sputtering chamber 22.

Page 32, line 18 to page 33, line 18:

In this sputtering chamber 22, the transparent substrates ~~2~~ 12 loaded on the pallet are conveyed at a speed of 25 cm/min. At the first target, a mixed gas of Ar and N_2 (Ar: 80 vol%, N_2: 20vol%) is introduced through the first valve, and a chromium nitride (CrN) film formed as the first shading film (light-shielding film, opaque film, non-transmitting film) 13 (see Figure 3 (a)) in a thickness of 150 Å by reactive sputtering. At the second target, a mixes gas of Ar, CH_4, and He (Ar: 30 vol%, CH_4: 10 vol%, He: 60 vol%) is introduced through the second valve, and a chromium carbide (CrC) film filmed as the second shading film (light-shielding film, opaque film, non-transmitting film) 14 (see Figure 3 (b)) in a

thickness of 600 Å by reactive sputtering. Then, at the third target, a mixed gas of Ar and NO (Ar: 80 vol%, NO: 20 vol%) is introduced through the third valve, and a chromium oxynitride (CrON) film is formed as the anti-reflective film ~~5~~ 15 (see Figure 3 (c)) in a thickness of 250 Å by reactive sputtering. Three layers of film are thus formed continuously. The pressure inside the sputtering chamber 22 during the film formation was 0.3 Pa, the sputtering power at the target for the second shading film 14 (light-shielding film, opaque film, non-transmitting film) was 1650 W, and the deposition rate of the above-mentioned second shading film 14 (light-shielding film, opaque film, non-transmitting film) was 3.4 nm/sec.

Page 33, line 19 to page 34, line 4:

After this, the pallet is moved into the vacuum-purged exit chamber 23. Once the sputtering chamber 22 and the exit chamber 23 have been completely separated by the partition, the exit chamber 23 is returned to atmospheric pressure. This yields a photomask blank 31. The pallets are continuously introduced, one after another, into the sputtering chamber 22 when the entry chamber 21 has reached the same state of vacuum as the sputtering chamber 22, so that at all times a plurality of pallets have been introduced into the sputtering chamber 22.

Page 34, lines 5-10:

A commercially available apparatus was used to measure the optical characteristics of the photomask blank 31 produced in this manner, whereupon the optical density was 3.0 and the surface reflectance was 12% at a wavelength of 365 nm. Also, no particles were generated from the pallets and there were no film defects, meaning that film quality was good.

Page 34, line 13 to page 35, line 2:

Figure 10 shows the results of analyzing the film composition of the photomask blank 31 thus obtained. Auger electron spectroscopy (AES) was used in the film composition analysis in Figure 10. Since helium content is not detected with Auger electron spectroscopy, the film composition analysis results in Figure 10 show the relative content when the total amount in which other elements (chromium, oxygen, nitrogen, carbon, silicon) were contained, excluding the helium content, was 100 at%. It can be seen from the measurement results obtained by Auger electron spectroscopy in Figure 10 that the composition varies continuously for the films that make up the photomask blank ~~11~~ 31 formed by inline sputtering.

Page 35, lines 3-8:

More specifically, in the anti-reflective film 15 and the second shading film 14 (light-shielding film, opaque film, non-transmitting film), the oxygen content continuously decreased and the carbon content continuously increases from the thin film surface side toward the transparent substrate 12 side, and nitrogen is contained in both of these films.

Page 36, lines 3-9:

The nitrogen in the nitride film of the first shading film 13 (light-shielding film, opaque film, non-transmitting film) is contained in a relatively larger amount than the nitrogen contained in a the anti-reflective film and the second shading film 14 (light-shielding film, opaque film, non-transmitting film), and the nitrogen content varies continuously.

Page 36, lines 10-25:

The nitrogen in the first shading film 13 (light-shielding film, opaque film, non-transmitting film) is included to prevent film defects (black spots) in the pattern, as well as to improve adhesion to the transparent substrate. The etching rate can be raised by including nitrogen in a relatively larger amount than the nitrogen contained in the anti-reflective film 15

and the second shading film 14 (light-shielding film, opaque film, non-transmitting film), so film residue (black spots) left by etching can be prevented. The nitrogen content is 0 to 65 at%, and the amount should average 5 to 60 at% in the film. In addition to nitrogen, the first shading film 13 (light-shielding film, opaque film, non-transmitting film) may also contain small amounts of carbon and oxygen.

Page 37, lines 5-19:

In order to better control these optical characteristics and the etching rate for obtaining the desired pattern shape, the photomask blank 31 of the present invention is structured such that in the anti-reflective film 15 and the second shading film 14 (light-shielding film, opaque film, non-transmitting film), the oxygen content continuously decreases and the carbon content continuously increases from the thin film surface side toward the transparent substrate 12 side, the nitrogen in the nitride film if the first shading film 13 (light-shielding film, opaque film, non-transmitting film) is contained in a relatively larger amount than ~~he~~ the nitrogen contained in the anti-reflective film 15 and the second shading film 14 (light-shielding film, opaque film, non-transmitting film), and the nitrogen content varies continuously.

Page 37, lines 20-24:

Also, just as in Example 1 above, the photomask blank ~~11~~ 31 was analyzed by thermal desorption gas analyzer (TDS), and desorption of the mass number (m/e) = 4 (He) was observed just as above, confirming that helium (He) was contained in the film.

Page 38, lines 1-6:

The change in flatness was measured by the same method as described above which confirmed that here was little change (-0.75 μm) and there was little film stress. The positional precision of the mask pattern was also extremely good in a photomask 32 produced by the same method as in Example 1.

Page 38, lines 7-10:

Since the films whose composition varied continuously were formed by inline sputtering, there were no abrupt steps between the films in a cross section of the patterns of the photomask 32, and a smooth, vertical pattern was obtained.

Page 38, lines 11-23:

When films were thus formed on a transparent substrate 12, the introduction of helium gas into the atmosphere gas in the formation of a chromium carbide film containing chromium and carbon in which the film stress exhibited tensile stress changes, and a chromium oxide film containing chromium and oxygen, and especially a thick chromium carbide film (CrC), allowed film stress to be suppressed and made it possible to obtain a film with no film stress even in the chromium oxynitride (CrON) film containing oxygen that was continuously formed over the chromium carbide film. Furthermore, the application of inline continuous sputtering allowed a photomask blank 31 with good film quality to be obtained while still permitting mass production.

Changes to Claims:

The following are marked-up versions of the amended claims:

1. (Amended) A photomask blank comprising at least a thin film having ~~at least~~ a shading function ~~(light-shielding function, opaque function, non-transmitting function)~~ formed over a transparent substrate,

wherein the thin film contains a metal material, and contains helium to such an extent that the film stress of the thin film can be reduced to be a desired film stress.

2. (Amended) A photomask blank comprising a thin film having at least a shading function ~~(light-shielding function, opaque function, non-transmitting function)~~ formed over a transparent substrate,

wherein the thin film contains a metal material and the thin film is formed by sputtering in which a sputtering target is disposed in a vacuum chamber into which an atmosphere gas has been introduced, and

the thin film is formed at a deposition rate of 0.5 nm/sec to 6 nm/sec, and the helium gas content is 30 to 90 vol% in the atmosphere gas.

4. (Amended) The photomask blank according to Claim 3, wherein the thin film is a laminated film including a shading function ~~(light-shielding film, opaque film, non-transmitting film)~~ that contains carbon, and an anti-reflective film that contains oxygen.

6. (Twice Amended) The photomask blank according to Claim 4, wherein the carbon content is 0 to 25 ~~at%~~ atomic% and the oxygen content is 0 to 75 ~~at%~~ atomic%.

10. (Twice Amended) The photomask blank according to Claim ~~1~~ 9, wherein the thin film has an oxygen content that continuously decreases and a carbon content that continuously increases from the thin film surface side to the transparent side, nitrogen is contained in the nitride film in a relatively greater amount than the amount of nitrogen contained in the thin film, and the amount of the metal decreases as the amount of nitrogen in the nitride film increases.

11. (Twice Amended) The photomask blank according to ~~Claims~~ Claim 1, wherein the thin film ~~contains~~ consists essentially of chromium.

13. (Twice Amended) A photomask blank ~~on~~ in which a mask pattern has been formed by the patterning of the thin film formed on the transparent substrate of the photomask blank ~~pertaining~~ according to the invention in Claim 1~~, or of the thin film and the nitride film~~.

14. (Amended) A method of manufacturing a photomask blank, in which a sputtering target is disposed in a vacuum chamber into which an atmosphere gas has been introduced, and at least a thin film having a shading function ~~(light-shielding function,~~

~~opaque function, non-transmitting function)~~ formed over a transparent substrate by sputtering,

wherein the thin film contains a metal material,

the correlation between the amount of helium gas contained in the atmosphere gas and the film stress of the thin film is determined ahead of time, and

the helium gas content is determined from said correlation so that the thin film will have a film stress such that the mask pattern obtained when the thin film is patterned will have the desired pattern position precision, and the thin film is formed by sputtering in an atmosphere gas having this helium gas content.

15. (Amended) A method of manufacturing a photomask blank, in which a sputtering target is disposed in a vacuum chamber into which an atmosphere gas has been introduced, and at least a thin film having a shading function ~~(light-shielding function, opaque function, non-transmitting function)~~ formed over a transparent substrate by sputtering,

wherein the thin film contains a metal material,

the thin film is formed at a deposition rate of 0.5 nm/sec to 6 nm/sec, and

the atmosphere gas contains helium gas.

16. (Amended) A method of manufacturing a photomask blank, in which a sputtering target is disposed in a vacuum chamber into which an atmosphere gas has been introduced, and at least a thin film having a shading function ~~(light-shielding function, opaque function, non-transmitting function)~~ formed over a transparent substrate by sputtering,

wherein the thin film contains a metal material,

the thin film is formed at a sputtering power of 950 to 3000 W, and

the atmosphere gas contains helium gas.

23. (Twice Amended) The method of manufacturing a photomask blank according to Claim 14, wherein the thin film ~~contains~~ consists essentially of chromium.

Translation of a part of the Description

Fig. 11 is a graph of the relationship between gas pressure and substrate warping (change in flatness) in the formation of the CrC film of a conventional photomask blank.

BEST MODE FOR CARRYING OUT THE INVENTION

Example 1

Figure 1 is a cross section of the photomask blank pertaining to Example 1, and Figure 2 is a cross section of the photomask in Example 1.

With the photomask blank 1 pertaining to Example 1 shown in Figure 1, a quartz glass substrate measuring 5 inches × 5 inches × 0.09 inch and whose main surface and end faces had undergone precision polishing was used as the transparent substrate 2. Over this transparent substrate 2 were formed a chromium nitride (CrN) film (Cr: 80 atomic at%, N: 20 atomic (hereafter called at%) at%; film thickness: 150 Å) as a first shading film (light-shielding film, opaque film, non-transmitting film) 3, a chromium carbide (CrC) film (Cr: 94 at%, C: 6 at%; film thickness: 600 Å) as a second shading film (light-shielding film, opaque film, non-transmitting film) 4, and a chromium oxynitride (CrON) film (Cr: 30 at%, O: 45 at%, N: 25 at%; film thickness: 250 Å) as an anti-reflective film 5.

示すグラフであり、第１１図は従来のフォトマスクブランクのＣｒＣ膜形成の際のガス圧と基板の反り（平坦度変化量）との関係を示すグラフである。

発明の実施をするための最良の形態

（実施例１）

第１図は実施例１に係るフォトマスクブランクの断面図、第２図は実施例１のフォトマスクの断面図である。

第１図に示す実施例１に係るフォトマスクブランク１では、透明基板２として、両主表面及び端面が精密研磨された５インチ×５インチ×０．０９インチの石英ガラス基板を用いている。そして、前記透明基板２上に、第１遮光膜３としての窒化クロムＣｒＮ（Ｃｒ：８０原子％、Ｎ：２０原子％（以下、ａｔ％という）、膜厚：１５０オングストローム）、第２遮光膜４としての炭化クロムＣｒＣ膜（Ｃｒ：９４ａｔ％、Ｃ：６ａｔ％、膜厚：６００オングストローム）、反射防止膜５としての酸化窒化クロム（ＣｒＯＮ）膜（Ｃｒ：３０ａｔ％、Ｏ：４５ａｔ％、Ｎ：２５ａｔ％、膜厚：２５０オングストローム）が形成されている。

ここで、反射防止膜５（ＣｒＯＮ膜）における表面反射率は、反射防止膜５中に含まれる酸素と窒素の含有量によって決まり、膜厚を適宜調整することによって制御する。なお、一般に表面反射率を制御する上で、露光光の波長付近で膜厚に対する反射率依存性が少なくなるように組成が選択される。

そして、第２図に示すフォトマスク１１は、第１図のフォトマスクブランク１をエッチングすることにより形成される